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FISH PREY OF THE ANTARCTIC FUR SEAL *ARCTOCEPHALUS GAZELLA* AT SOUTH GEORGIA

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Abstract. A small collection of otoliths was obtained from scats of sub-adult male Antarctic fur seals *Arctocephalus gazella* at Bird Island, South Georgia. A reference collection of otoliths from South Georgia fish was used to identify the material and to derive relationships between otolith length and fish weight which were then applied to the sample otoliths, after correcting for loss of material during digestion.

The pelagic icefish *Chamsocephalus gunnari* was the main prey, in terms of numbers (55%) and weight (76%) of fish consumed. Other species taken include the lantern fish *Gymnoscopelus nicholsi*, the nototheniids *Notothenia rossii*, *Notothenia gibberifrons*, and *Patagonotothen larseni* and *Pseudochaenichthys georgianus*. The estimated mean weight of the *C. gunnari* specimens was 160 g (range 45–560 g) and most were young adults aged 3–5 years; individuals of other species were mainly much smaller.

Individual scat samples contained remains which represented a weight of 80–2000 g of fish, and in all but one case a single species accounted for over 80% of this. Fish formed a very small portion of the fur seals' diet in summer. The fish taken were mainly epi-pelagic, krill-feeding species. This is in line with the diet and diving patterns of *A. gazella* which feeds principally on krill in the upper water layer, and it is likely that the seals take fish from shoals associated with krill. Studies of otolith digestion rates and more data on relationships between otolith length and fish weight would greatly improve the future analysis in similar studies.

Introduction

Seals are important top predators in most marine ecosystems and especially so in the Southern Ocean (Laws, 1977). However it is diffcult to obtain appropriate samples with which to study their diet quantitatively and, partly for this reason, estimates of their impact on prey stocks are very provisional.

Information on the composition of their diet results mainly from examination of stomach contents of animals collected, often when hauled out at their breeding sites. Usually only a small proportion of these animals have food remains in their stomach. Quantitative assessments also depend on the material present being representative of the material orginally ingested.

A common bias is the overestimation of the importance of squid because their hard, keratinous beaks accumulate in the stomachs of predators (Clarke, 1980), including Antarctic seals (Clarke and MacLeod, 1982*a*, *b*; Lipinski and Woyciechowski, 1981). A second bias is probably underestimation of the importance of fish, as this is the most rapidly digested of prey types taken by seabirds (Croxall and Prince, 1980*a*; Prince *a*, *b*), and identifiable hard parts (eg, otoliths) are small and probably pass out in the faeces.

Considerable use has been made of otoliths to determine the age of fish (Bagenal, 1974) and it is known that the otoliths of different species tend to have characteristic shapes and structures which may permit identification of the fish when only otoliths are available (Yukhov, 1971). A few studies have identified fish prey from otoliths in seal scats (Anderson and others, 1974; Pitcher, 1980 and references therein). However, it should be possible to derive information on the age, length and weight of the fish taken by predators if standard relationships between otolith size and these parameters can be developed. Few such relationships exist for any fish (see Frost and Lowry, 1981 and references cited) and none for Antarctic species.

We report here the results of a preliminary attempt to study the fish eaten by Antarctic fur seals *Arctocephalus gazella* at Bird Island, South Georgia, by analysing the otoliths present in their faeces in conjunction with a reference collection of material from fish caught at South Georgia. Although Antarctic fur seals mainly eat krill *Euphausia superba*, fish has been recorded in their diet (Bonner, 1968) but its nature and importance is unknown.

METHODS

Collection of samples

The original sampling objective was to collect randomly 50 scat samples per month from the vicinity of the fur seal breeding beaches. The samples collected from November 1982 to March 1983 contained only remains of krill; after December samples likely to contain fish (i.e. of whitish-grey colour) were actively sought. Six such scats were collected in February and one each in January and March, all from tussock grassland behind the beaches, areas almost solely populated by sub-adult (aged about two to six years) male seals.

Each sample was individually washed through sieves, the finest with a mesh diameter of 0.5 mm. All otoliths were removed, dried and then stored in filter-paper packets within labelled envelopes for further analysis at Cambridge. Special care was taken to extract the smallest otoliths and it is unlikely that any were overlooked.

Analysis of reference material

The reference set of otoliths (sagitta) was made using specimens removed directly from freshly caught fish and stored dry. They were drawn using a binocular microscope with a drawing tube. Maximum (anterior–posterior) length in the sagittal plane was measured from the drawings and converted into true length. Relationships between length and fish weight were investigated by fitting linear (least squares) regressions to the log-transformed data. The relationships, which are of the form $Y = aX^b$, where Y is the fish weight in g, X the otolith length in mm and a (intercept) and b (slope) the regression coefficients, are illustrated for three species in Figs. 1–3. The

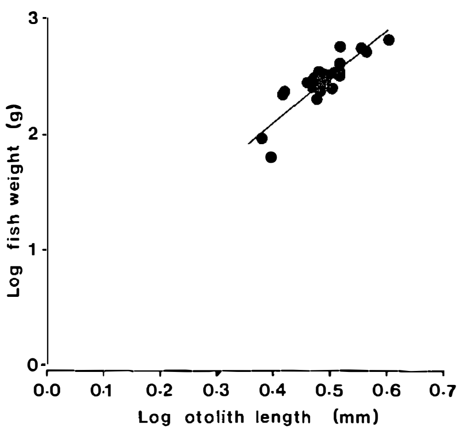

Fig. 1. Log-log relationship between fish weight and otolith length in *Champsocephalus gunnari*.

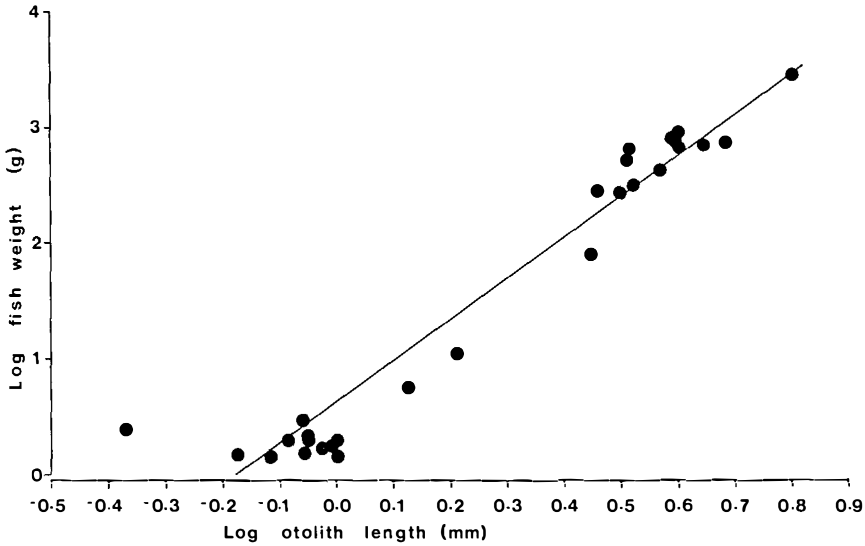

Fig. 2. Log-log relationship between fish weight and otolith length in *Notothenia rossii*.

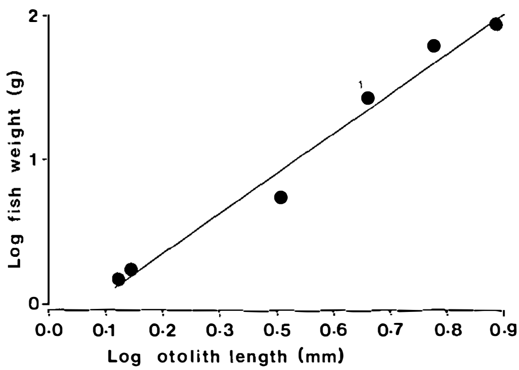

Fig. 3. Log-log relationship between fish weight and otolith length in *Patagonotothen larseni*. 1. Value derived from data in Targett (1981).

regression statistics are summarized in Table I and indicate good correlation between otolith length and fish weight in all cases. For other species, measurements were only available from otoliths longer than those in the seal samples. Approximate fish weights were obtained for these by extrapolating assumed log-linear length-weight relationships.

Table I. Regression coefficients (± one standard deviation) and correlation coefficients of relationships between otolith length (mm) and fish weight (g).

Species	Sample size (n)	Slope (b)	Intercept (a)	Log intercept (log a)	Correlation coefficient (r)
Champsocephalus gunnari	24	4.048 ± 0.453	3.087	0.490 ± 0.221	0.88
Notothenia rossii	28	3.549 ± 0.263	4.205	0.624 ± 0.112	0.97
Patagonotothen larseni	5	2.735 ± 0.259	0.635	−0.198 ± 0.132	0.99

Analysis of samples

The dried otoliths from the scat samples were identified by comparison with the reference material and drawn and measured as described above. The measurements of length, however, need to be corrected for the reduction in otolith size due to digestion during their passage through the seal's gut. There are few quantative data on this subject. Prime (1979) investigated the digestion of otoliths from four species of gadoid fish fed to the common seal *Phoca vitulina*. For otoliths between 1.28 and 2.38 mm in width, digestion was between 15 and 50% of width with a mean of 38.5%. The morphology of the otoliths from fur seals was compared with that of undigested material and the amount of digestion assessed. *Champsocephalus gunnari* otoliths appeared to have lost 10–20% of their length whereas the less dense nototheniid (*Patagonotothen*, *Notothenia*) types, were about 15–25% digested. In view of the subjective nature of these estimates it is assumed here that otoliths of all fish species had lost 20% of their length and measurements were corrected accordingly. This value is appreciably lower than in common seals which may reflect that gut retention times in otariid seals are much shorter than the 16 h recorded by Prime (R. Gentry, pers. comm.).

Fish have a pair of sagittal otoliths, which are used for identification purposes. Therefore the estimates of the number and total weight of fish eaten were divided by two, although both otoliths would not necessarily be present in the same scat sample.

Ages were estimated by comparison with otolith dimensions of aged fish in the reference collection and by using data on size-age relationships from Olsen (1955) and Kock (1981, 1982).

Results

The identification and measured (uncorrected) lengths of all 92 otoliths collected are given in Appendix 1, together with estimates of the corrected and uncorrected weight and age of the fish from which they derive.

Some otoliths from nototheniid fish could only be assigned to a species group rather than positively identified to species. In Appendix 1 these are recorded under the name of the species which they most resemble. They were combined with material of that species for estimation of weight and age. The *N. gibberifrons* aggregation (agg.) includes *N. rossii* and *N. hansoni*; the *P. larseni* agg. includes *N. nudifrons* and *N. angustifrons*.

Thirteen otoliths could not be identified to species or species-group. One belonged to the genus *Notothenia*. Ten certainly (and possibly an eleventh) belonged to a single taxon (Species A), which is presently unidentifiable. The weight estimates derived for these are very provisional.

The composition of material from all samples combined (Table II) emphasises the importance of *Champsocephalus gunnari*, which contributes 55% of the otoliths and 76% of the estimated weight consumed. Of the other species only *Gymnoscopelus nicholsi* (see Hulley, 1981; also known as *G. aphya*, McGinnis, 1982), *Patagonotothen larseni* (formerly *Notothenia larseni*, Andersen and Hureau, 1979), and Species A contribute more than 10% of the otoliths and none of these makes a really significant contribution by weight.

In estimating the weight of the fish taken the importance of allowing for the effect of digestion is demonstrated by comparing the values for corrected and uncorrected weights in Table II. Thus a 20% reduction of otolith length results in a 230% underestimate of the overall weight of the fish taken, including a 250% underestimate for *C. gunnari* alone.

Table II. Composition, by numbers and estimated weight, of the fish eaten by Antarctic fur seals.

			*Estimated weight**			
	Otoliths		*Uncorrected*		*Corrected*†	
Species	*n*	%	*g*	%	*g*	%
Champsocephalus gunnari	51	55.4	1662	71.5	4100	76.0
Patagonotothen larseni	12	13.0	108	4.7	199	3.7
Notothenia gibberifrons	3	3.3	111	4.8	203	3.8
Notothenia rossii	1	1.1	112	4.8	249	4.6
Gymnoscopelus nicholsi	10	10.9	54	2.3	83	1.5
Notothenia hansoni	1	1.1	16	0.7	32	0.6
Pseudochaenichthys georgianus	1	1.1	5	0.2	14	0.3
Species A	10	10.9	250	10.8	500	9.3
Other unidentified	3	3.3	8	0.3	15	0.3
Total	92		2326		5395	

* Divided by two on the assumption that two otoliths from each fish were present.
† Allowing for 20% of otolith length lost by digestion.

The uncorrected length distribution of the otoliths from the seal scats (Fig. 4) shows that those of *C. gunnari* span a smaller size range than otoliths of the other species. In contrast the distribution of the estimated weight of fish taken (Fig. 5) shows that the *C. gunnari* were significantly heavier than other fish. The average corrected weights of the three important species are given in Table III. The only fish taken of comparable size to the *C. gunnari* were one *N. gibberifrons* (272 g) and one *N. rossii* (497 g). The *C. gunnari* eaten were mainly 3–5 years old (range 2–10 years), the *G. nicholsi* were less than 3 years old and the large *N. gibberifrons* and *N. rossii* were 7–10 and 4 years old, respectively.

Despite the overall dominance of *C. gunnari* it is not the most important species in every sample (Table IV), of which seven out of eight samples were dominated by a single species of fish. Sample 8 was anomalous in that all three fish species taken were equally important, and two of them were not represented in any other sample.

In each individual scat sample the otolith remains were estimated to represent 80–1993 g of fish (mean 675 g ± 636). Fur seals need to eat about 17% of their body

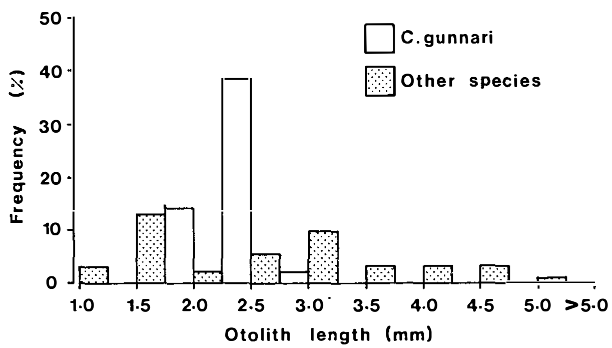

Fig. 4. Length distribution of otoliths from Antarctic fur seal samples. Unshaded, *Champsocephalus gunnari*; stippled, all other species.

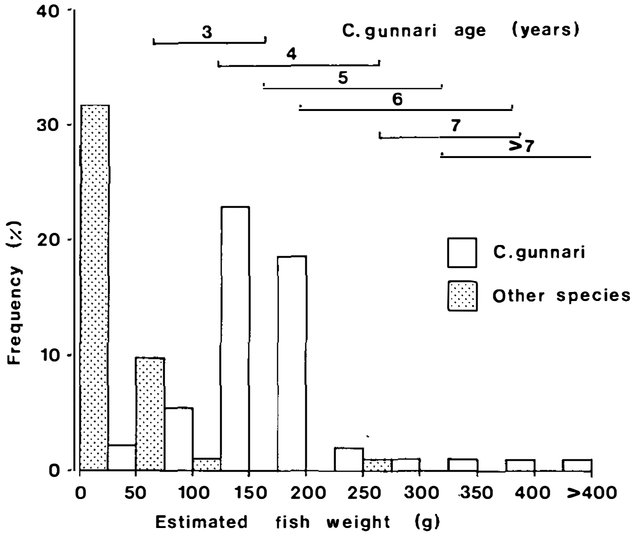

Fig. 5. Distribution of estimated corrected weight of fish taken by Antarctic fur seals. Unshaded, *Champsocephalus gunnari*; stippled, all other species. The range of weight of known age specimens of *C. gunnari* is shown by the horizontal bars.

weight per day (Kooyman and others, pers. comm. from unpublished data), so 2–5-year-old males weighing 30–60 kg (Payne, 1979) require 5–10 kg of food each day. The fish contents of the scats represented between 1% and 40% (mean *c.* 10%) of their daily requirement.

Table III. Estimated corrected weight of fish taken by the Antarctic fur seal.

Species	*Number of otoliths*	*Weight (g)*		
		Mean	*S.D.*	*Range*
Champsocephalus gunnari	51	161	81	44–559
Patagonotothen larseni	12	33	26	5–84
Gymnoscopelus nicholsi	10	17	6	9–32

Table IV. Composition of fish prey in individual fur seal scat samples.

Sample no.	*Weight of fish (g)*	*Main prey species*	*Percent by weight of sample*	*Other species*
1	1112	*Champsocephalus gunnari*	95.9	*Notothenia hansoni, Patagonotothen larseni*
2	506	*Champsocephalus gunnari*	83.5	*Patagonotothen larseni, Pseudochaenichthys georgianus*
3	243	*Notothenia gibberifrons*	83.7	*Patagonotothen larseni*
4	1993	*Champsocephalus gunnari*	100	
5	454	*Champsocephalus gunnari*	100	
6	80	*Patagonotothen larseni*	100	
7	164	*Champsocephalus gunnari*	100	
8	844	Species A	59	*Notothenia rossii, Gymnoscopelus nicholsi*

Discussion

On the evidence of this small collection of otoliths, the pelagic icefish *Champsocephalus gunnari* is the most important element of the fish diet of sub-adult male Antarctic fur seals at South Georgia during the summer. *C. gunnari* matures sexually at age 3 years unlike many other Antarctic fishes which do not mature until age 5–8 years (Everson, 1977). Therefore it is mainly young adults that are taken by seals. *C. gunnari* and *P. larseni* are both epi-pelagic and feed predominantly on krill (Permitin and Tarverdieva, 1978; Targett, 1981); *P. georgianus* is also epi-pelagic but the myctophid lanternfish *G. nicholsi* may also be mesopelagic (McGinnis, 1982) although it is often found with krill swarms in sub-surface waters (Rembiszewski and others, 1978). The other fish taken are chiefly bentho-demersal (Burchett and others, 1983) but may sometimes feed on krill (Permitin and Tarverdieva, 1978; Linkowski and Rembiszewski, 1978).

During the summer female fur seals at South Georgia feed almost exclusively on mature krill (Bonner, 1968; Croxall and Prince, 1980). Their diving patterns reflect the diurnal vertical migration of krill, most feeding being during shallow dives at night when much krill is between the surface and 30 m depth, although daytime dives to 100 m are recorded (Croxall and others, in press). If diving patterns of young males are similar it is not suprising that their main fish prey should be epi-pelagic, krill-feeding species and likely that they opportunistically take fish which are associated with krill swarms. The data on the composition of individual scats suggest that they mainly encounter single-species fish schools.

Foraging activities of breeding female fur seals are probably confined to the South Georgia continental shelf and shelf slope areas (Croxall and others, in press). If young males feed in similar areas the virtual absence from the diet of *N. rossii*, the most common nearshore fish species at South Georgia (Burchett, 1983), is perhaps surprising. As sub-adult males are at sea for longer periods than breeding females they may lead a more pelagic existence. Alternatively the predominantly benthic habit of *N. rossii* and the recent reduction in abundance of this species (Burchett and Ricketts, pers comm.), may make it less suitable prey for fur seals.

In summer the level of seal predation on fish stocks, even that of *C. gunnari*, must be very low, with so few scats containing fish remains. However, male fur seals, especially immature individuals, are increasingly common around South Georgia during the winter (P. G. Copestake, P. A. Prince, pers. comms.), and the colour of their faeces in early spring (August–September) suggest that fish are present in at least 50% of scats (Prince, in Osborne, 1983). Therefore predation by seals might be a factor in the population dynamics of *C. gunnari* which is also heavily fished (Sahrhage, 1979; Kock, 1981). In winter fur seals may be more significant fish predators of *C. gunnari*, which forms large nearshore spawning aggregations in April and May (Olsen, 1955), and perhaps *N. rossii*.

Fish are a much more important component in the diet of other species of fur seal. The Cape fur seal *Arctocephalus pusillus* feeds mainly on fish, by volume chiefly maasbanker *Trachurus trachurus* (59%) and pilchard *Sardinops ocellata* (19%)(Rand, 1959). The diet of the New Zealand fur seal *A. forsteri* comprises 53% squid and 42% fish by weight, 80% of which is barracouta *Thyrsites atun* (Street, 1964). The Northern fur seal *Callorhinus ursinus* in the eastern North Pacific takes 18% squid and 82% fish by modified volume, mainly herring *Clupea harengus* and salmonids *Oncorhynchus* spp. (Perez and Bigg, 1981) though walleye pollock *Theragra chalcogramma* is the main prey in the eastern Bering Sea in summer (Perez and Bigg, in press). Fish dominate the diet of *C. ursinus* off California (Kajimura, 1981) with Pacific whiting *Merluccius productus* and anchovy *Engraulis mordax* predominating. The one element in common with the present study is that all these are surface fish and the seals are believed to prey on them mainly at night (Street, 1964; Kajimura, 1981).

This preliminary study has shown that analysis of otoliths excreted in faeces can provide quite detailed quantitative information on the composition of the fish in the diet of seals. Additional data, however, would appreciably improve subsequent analyses. First, experimental investigations of the digestion rates of otoliths are required, as estimates of fish weights are very sensitive to changes in otolith length. Second, much more extensive reference collections are needed to refine statistical analyses of the relationship between otolith size, fish length and weight. Third, methods for estimating the rate of production of faeces and relating their composition to that of ingested material are required, although good correlation between stomach and faecal content has been reported for common seals (Pitcher, 1980).

Acknowledgements

We thank P. G. Copestake and B. C. Osborne for assistance in the field, M. S. Burchett for *Notothenia rossii* otoliths and information, M. G. White for help in accumulating otolith data, P. A. Prince for providing unpublished information and S. McInnes for preparing the illustrations. M. G. White and especially J. H. Prime made constructive comments on the manuscript.

Received 7 June 1983; accepted 17 June 1983

References

Andersen, N. C. *and* Hureau, J. C. 1979. Proposition pour une nouvelle classification des Nototheniidae (Pisces, Perciformes, Nototheniidae). *Cybium*, 3e serie, **6,** 47–53.

Anderson, S. S., Bonner, W. N., Baker, J. R. *and* Richards, R. 1974. Grey seals *Halichoerus grypus* of the Dee Estuary and observations on a characteristic skin lesion in British seals. *Journal of Zoology, London*, **174,** 429–40.

Bagenal, T. B. (*Ed.*) 1974. *Ageing of fish*. Proceedings of an International Symposium Organised by the European Inland Fisheries Advisory Commission of FAO, The Fisheries Society of the British Isles and the Freshwater Biological Association, at the University of Reading, England, 234 pp.

Bonner, W. N. 1968. The fur seal of South Georgia. *British Antarctic Survey Scientific Reports*, No. 56, 81 pp.

Burchett, M. S. 1983. Abundance of the nearshore fish populations at South Georgia (Antarctica) sampled by trammel net. *British Antarctic Survey Bulletin*, No. 61, 39–43

Burchett, M. S. In press. Age determination of *Notothenia rossii* Fischer (1885) from South Georgia (Antarctica) using scales and otoliths. *Cybium*.

Burchett, M. S., Sayers, P. J., North, A. W., *and* White, M. G. 1983. Some biological aspects of the nearshore fish populations at South Georgia. *British Antarctic Survey Bulletin*, No. 59, 63–74.

Chojnacki, J. *and* Palczewski, P. 1981. Age and growth rate of *Pseudochaenichthys georgianus* Norman, 1937 (family Chaenichthyidae) of the South Georgia region. *Polish Polar Research*, **2,** No. 3–4, 145–57.

Clarke, M. R. 1980. Cephalopoda in the diet of sperm whales of the Southern Hemisphere and their bearing on sperm whale biology. *Discovery Reports*, **37,** 1–324.

Clarke, M. R. *and* MacLeod, N. 1982*a*. Cephalopods in the diet of elephant seals at Signy Island, South Orkney Islands. *British Antarctic Survey Bulletin*, No. 57, 27–31.

Clarke, M. R. *and* MacLeod, N. 1982*b*. Cephalopod remains in the stomachs of eight Weddell seals. *British Antarctic Survey Bulletin*, No. 57, 33–40.

Croxall, J. P. *and* Prince, P. A. 1980*a*. Food, feeding ecology and ecological segregation of seabirds at South Georgia. *Biological Journal of the Linnean Society*, **14,** 103–31.

Croxall, J. P. *and* Prince, P. A. 1980*b*. The food of gentoo penguins *Pygoscelis papua* and macaroni penguins *Eudyptes chrysolophus* at South Georgia. *Ibis*, **122,** 245–53.

Croxall, J. P., Everson, I., Kooyman, G. L., Ricketts, C. *and* Davis, R. W. In press. Fur seal diving behaviour in relation to vertical distribution of krill. *Polar Biology*.

EVERSON, I. 1977. *The living resources of the Southern Ocean.* Food and Agriculture Organisation GLO/SO/77/1 Rome, 1–156.

FROST, K. J. *and* LOWRY, L. F. 1981. Trophic importance of some marine gadoids in northern Alaska and their body–otolith size relationships. *Fishery Bulletin*, **79,** 187–92.

HULLEY, P. A. 1981. Results of the research cruises of FRV "Walther Herwig" to South America LVIII. Family Myctophidae (Osteichthys, Myctophiformes). *Archiv für Fischereiwissenchaft,* **31,** Beih. 1, 1–300.

KAJIMURA, H. 1981. The opportunistic feeding of northern fur seals off California. Northwest and Alaska Fisheries Centre, NMFS, NOAA, Seattle, unpublished report, 25 pp.

KOCK, K-H. 1981. Fischereibiologische Untersuchungen an drei antarktischen Fischarten: *Champsocephalus gunnari* Lonnberg, 1904, *Chaenocephalus aceratus* (Lonnberg, 1905) und *Pseudochaenichthys georgianus* Norman, 1937 (Notothenioidei, Channichthyidae). *Mitteilungen aus dem Institut für Seefischerei der Bundesforschungsanstalt für Fischerei, Hamburg*, No 32, 226 pp.

KOCK, K-H. 1982. Fischereibiologische Untersuchungen bei Elephant Island Im Marz 1981. *Archiv für Fischereiwissenschaft*, **33,** Beih. 1, 127–42.

LAWS, R. M. 1977. Seals and Whales of the Southern Ocean. *Philosophical Transactions of the Royal Society*, Series B, **279,** 81–96.

LINKOWSKI, T. B. *and* REMBISZEWSKI, J. M. 1978. Ichthyological observations off the South Georgia coasts. *Polish Archives of Hydrobiology,* **25,** 697–704.

LIPINSKI, M. *and* WOYCIECHOWSKI, M. 1981. Cephalopods in the food of Weddell seals from the Admiralty Bay (King George Island, South Shetland Islands). *Polish Polar Research*, **2,** 163–7.

MCGINNIS, R. F. 1982. Biogeography of lanternfishes (Myctophidae) south of 30° S. *Antarctic Research Series,* **35,** 1–110.

OLSEN, S. 1955. A contribution to the systematics and biology of the Chaenichthyid fishes from South Georgia. *Nytt Magasin fur Zoologie,* **3,** No. 1, 79–93.

OSBORNE, B. C. 1983. Bird and mammal report: Bird Island 1982–83. [British Antarctic Survey unpublished report].

PAYNE, M. R. 1979. Growth in the Antarctic fur seal *Arctocephalus gazella. Journal of Zoology, London,* **187,** 1–20.

PEREZ, M. A. *and* BIGG, M. A. 1981. Modified volume: a two step frequency-volume method for ranking food types found in stomachs of northern fur seals. Northwest and Alaska Fisheries Centre, NMFS, Seattle, unpublished report, 25 pp.

PEREZ, M. A. *and* BIGG, M. A. In press. Food habits of northern fur seals (*Callorhinus ursinus*) off western North America. (*In* BEDDINGTON, J., BEVERTON, R. J. *and* LAVIGNE, D. M. *Marine mammal – fishery interactions.* London, Allen and Unwin.)

PERMITIN, Yu. E. *and* TARVERDIEVA, M. I. 1978. Feeding of fishes of the family Nototheniidae and Chaenichthyidae in the South Orkney Islands. *Soviet Journal of Marine Biology,* **4,** No. 2, 619–22.

PITCHER, K. W. 1980. Stomach contents and faeces as indicators of harbour seal, *Phoca vitulina*, foods in the Gulf of Alaska. *Fishery Bulletin,* **78,** 797–8.

PRIME, J. H. 1979. Observations on the digestion of some gadoid fish otoliths by a young common seal. *International Council for the Exploration of the Sea*, CM 1979/N: 14, 3 pp.

PRINCE, P. A. 1980*a*. The food and feeding ecology of the blue petrel *Halobaena caerulea* and dove prion *Pachyptila desolata. Journal of Zoology, London,* **190,** 59–76.

PRINCE, P. A. 1980*b*. The food and feeding ecology of the grey headed albatross *Diomedea chrysostoma* and black-browed albatross *D. melanophris. Ibis,* **122,** 476–88.

REMBISZEWSKI, J. M., KRZEPTOWSKI, M. *and* LINKOWSKI, T. B. 1978. Fishes (Pisces) as by-catch in fisheries of krill *Euphausia superba* Dana (Euphausincea, Crustacea). *Polish Archives of Hydrobiology,* **25,** 677–95.

RAND, 1959. The Cape fur seal (*Arctocephalus pusillus*): distribution, abundance and feeding habits off the southwestern coast of the Cape Province. *Division of Fisheries Investigational Report*, No. 34, 75 pp.

SAHRHAGE, D. (*Ed.*) 1979. Antarctic fish biology. *BIOMASS Report Series*, No. 3, 35 pp.

STREET, R. J. 1964. Feeding habits of the New Zealand fur seal *(Arctocephalus forsteri). New Zealand Marine Department Fisheries Technical Report,* No. 9, 20 pp.

TARGETT, T. E. 1981. Trophic ecology and structure of coastal Antarctic fish communities. *Marine Ecology Progress Series,* **4,** 243–63.

WHITE, M. G. *and* NORTH, A. W. 1979. Offshore biological programme: ichthyological data. *British Antarctic Survey Data Report*, No. 2, 24 pp.

YUKHOV, V. L. 1971. Otolith structure in the Antarctic and Patagonian Blennies (*Dissostichus mawsoni* (Norm.) and *D. eleginoides* (Smitt)) (Family Nototheniidae) of the Antarctic Ocean. *Journal of Ichthyology,* **11,** 485–92.

APPENDIX

Details of fish eaten by Antarctic fur seals.
Column 1: Otolith length/mm.
Column 2: Estimated weight/g – uncorrected.
Column 3: Estimated weight/g – corrected.
Column 4: Estimated age/years.

Notes:
1. Aged using data from Kock (1981, 1982) and Chojnacki and Palczewski (1981).
2. Aged using data from White and North (1979).
3. Aged using data from Burchett (in press *b*).
4. A single weight estimate, applied to all specimens, was derived from the combined data for all species. It is probably a slight overestimate.

Sample no. 1, 10 January 1983

Champsocephalus gunnari			
2.05	57	139	3–4
2.19	74	182	4
2.19	74	182	4
2.12	65	160	3–4
2.19	74	182	4
1.90	42	102	3
1.97	48	119	3–4
2.05	57	139	3–4
2.05	57	139	3–4
2.05	57	139	3–4
2.41	109	268	5-6
2.63	155	382	7+
Patagonotothen larseni agg.			
3.11	14	26	–
Notothenia hansoni			
3.11	32	64	3–4

Sample no. 2, 4 February 1983

Champsocephalus gunnari			
2.27	85	211	4–5
2.19	74	182	4
2.05	57	139	3-4
1.97	48	119	3-4
1.86	38	94	3
1.54	18	44	2–3
1.64	23	57	2–3
Pseudochaenichthys georgianus[1]			
3.87	26	47	–
4.06	29	54	–
3.00	13	24	–
2.41	7	13	–
Pseudochaenichthys georgianus[1]			
1.68	11	29	2

Sample no. 3, 4 February 1983

Patagonotothen larseni agg.			
4.57	41	75	–
Notothenia gibberifrons[2]			
4.50	61	111	5
6.25	148	272	<10
2.54	13	23	<4
Notothenia sp.			
1.24	3	5	<1

Sample no. 4, 4 February 1983

Champsocephalus gunnari			
2.89	227	559	10+
2.12	65	157	3–4
2.12	65	157	3–4
2.16	70	172	4
2.05	57	139	3–4
2.22	80	192	4
2.19	74	182	4
2.07	59	145	3-4
2.05	57	139	3-4
1.83	36	88	2–3
1.94	45	111	3
1.94	45	111	3
2.05	57	139	3-4
1.83	36	88	2–3
2.05	57	139	3-4
2.27	85	211	4–5
2.07	59	145	3-4
2.16	70	172	4
2.12	65	160	3–4
2.05	57	139	3-4
2.21	77	189	4
2.05	57	139	3–4
2.49	124	306	5–7

Sample no. 5, 12 February 1983

Champsocephalus gunnari			
2.23	79	196	4–5
2.14	67	166	3–4
2.12	65	160	3–4
2.05	57	139	3-4
1.83	36	88	2–3
1.94	45	111	3
1.57	19	47	2–3

Sample no. 6, 15 February 1983

Patagonotothen larseni agg.			
4.77	46	84	–
2.92	12	22	–
2.67	9	17	–
2.78	10	19	–
2.39	7	13	–
1.75	3	5	–

Sample no. 7, 21 February 1983

Champsocephalus gunnari			
2.21	77	189	4
2.05	57	139	3-4

Sample no. 8, 8 March 1983

Gymnoscopelus nicholsi			
4.97	21	32	<3
4.09	14	22	<3
3.29	10	15	<3
3.66	12	18	<3
3.22	9	14	<3
3.29	10	15	<3
3.51	11	16	<3
3.16	9	13	<3
3.09	8	13	<3
2.61	6	9	<3
Notothenia rossii			
3.07	224	497	4
Species A			
1.83			
1.97	weight estimates[4]:		
1.94	<50 g (uncorrected)		
1.84	<100 g (corrected)		
1.94			
1.83			
1.84			
1.94			
183			
1.79			
1.79			
1.88			
1.75			
Species B			
1.46	<20	<36	–
unidentified			
1.06	<5	<10	-